

EFFECT OF HABITAT FRAGMENTATION ON DIVERSITY AND ABUNDANCE OF NESTING BIRDS IN AN URBAN LANDSCAPE: THE CASE OF MWALIMUNYERERE CAMPUS THICKETS, UNIVERSITY OF DAR ES SALAAM, TANZANIA

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ABSTRACT

Little is known of the nesting bird species in most of urban areas of East Africa. An investigation was made of the occurrence of breeding bird species in the fragmented thickets found in the Mwalimu Nyerere Campus of the University of Dar es Salaam, in the City of Dar es Salaam. The study examined how habitat fragmentation affects nesting bird species richness and diversity in the thickets. Systematic physical nest searches of breeding birds were conducted in the fragmented thickets. Searches were conducted in transects and they included inspecting vegetation, bare ground, cavities, stream (river) banks and other suitable nesting locations for the presence of active nests. Numbers and diversity of nesting bird species increased with fragment size which suggest that most nesting birds avoid smaller fragments and that reductions in size of habitat might negatively affect majority of the nesting bird species. For continued conservation of birds, protection of the remaining thicket fragments on the campus is recommended.

Keywords: fragmentation, nesting birds, thickets, campus of the University of Dar es Salaam, nest species diversity

INTRODUCTION

Habitat fragmentation, the process of subdividing continuous habitat into smaller patches (Andren 1994), is the most important threat to forested ecosystems (Bierregaard et al. 2001). It may occur naturally through fire (Picket and Thompson 1978) and gaps created by falling trees (Foster 1980) but the most important and large scale cause is anthropogenic through clearing for agriculture, road construction, urbanisation and other human development (Andren 1994, Tewskbury et al. 2006, Newmark and Stanley 2011). When a habitat is lost, not only is the overall area reduced, but the remaining habitat also becomes fragmented and there is an increase in distance between patches (Opdam et al. 1995). Knowledge on the effects of habitat fragmentation due to urbanisation is important because urban habitats differ in a

number of ways from the natural environment: for example, in urban areas, wooded habitats are extensively fragmented, vegetation cover is very sparse and some vegetation layers are lacking (Gilbert 1989).

Habitat fragmentation can result in population declines of birds by reducing adequate space for territories, nest sites, and other critical resources (Rolstad 1991). It has been shown to lead to extinction of some species that are dependent on the forest (Leck 1979, Newmark 1991, Kattanet al. 1994). Habitat fragmentation also can lead to changes in predator densities or numbers, and has been shown to increase predation pressure on forest birds and their nests (Andrén 1985).

Furthermore, habitat fragmentation also appears to affect the availability of food

resources which in turn can reduce bird fecundity (Zanette and Jenkins 2000). Habitat fragmentation can therefore dramatically impact avian reproduction success, either directly through reduced food availability, or indirectly through increases in predation pressure. It also leads to an increase in resistance to dispersal of birds between fragments (Opdam et al. 1995, Newmark et al. 2010).

Mwalimu Julius Kambarage Nyerere campus (here after campus) is an area of about 500 hectares which presently has *ca.* 180 hectares of woody vegetation in the form of bush thickets. As a result of construction of buildings (residential houses, lecture halls, offices and laboratories), roads, electricity power lines and the Songo Songo gas pipeline, the remaining thickets exist as fragments of different sizes. The thickets are currently surrounded by buildings, roads and cleared land.

Bird species present in the campus thickets are fairly well known (Harvey and Howell 1987, Mlingwa 1992). The thickets provide a habitat which is not available in most of the city of Dar es Salaam City as the majority of the other available thickets have been cleared for building construction and other urban development. The campus thickets have been shown to be an important habitat for a number of bird species including those which depend on the existence of forest for their survival (Mlingwa 1992) as well as Palaearctic migrants (Harvey and Howell 1987, Mlingwa 1992). While breeding is one of the crucial ecological aspects of bird population dynamics (Johnson 1979), systematic breeding studies of the campus thickets are non-existent. The breeding records of birds that are available in these thickets are those of Harvey and Howell (1987) and yet they are few. It is possible that with further clearing of the thickets, breeding of different bird species may be negatively affected. To

assess whether habitat fragmentation has affected breeding birds in this area since the campus was constructed in the 1960's, six fragments of different sizes were studied during the breeding season. In this study we attempted to (1) assess which bird species breed in the main campus thickets, and (2) ascertain whether habitat fragmentation has a negative effect on breeding bird species, both in terms of number of breeding species and abundance of nesting birds.

MATERIALS AND METHODS

Study area

The campus of the University of Dar es Salaam is situated about 10 km north-west of the Dar es Salaam city centre (6° 46' S - 6° 47' S, 39° 12' E - 39° 14' E) and is roughly 40 – 100 m above sea level. Mean annual temperature is about 24 °C and humidity is normally high reaching 100 % in January, February and March. It receives over 1,100 mm of rainfall per year (Senzota 2012).

The original natural vegetation on the campus was closed forest, most of which disappeared due to clearing for agriculture and building (Wingfield 1977). Construction of the first infrastructure on the campus was conducted between the early 1960's and mid 1970's (Senzota 2012). The campus had much of its natural vegetation removed in the early 1970's and by mid 1970's much of the vegetation in the form of large trees was cleared (Harvey and Howell 1987). However, there has been a considerable recovery of indigenous vegetation at the campus over the last 20 years mainly due to strict protection from fuel wood collection and cultivation (Senzota 2012). The woody vegetation that has been in existence is now fairly well protected and appears as a habitat island mostly vegetated by indigenous plants surrounded by high density human settlements. Within the remaining indigenous woody vegetation (hereafter thicket fragments), large trees (up to 20 m

high) can now be observed particularly along the stream valleys (C.W. Pers. observ.) The fragments are not continuously connected due to construction of buildings, roads, electricity power lines and the Songo Songo natural gas pipeline. The remaining thicket fragments are of different sizes and with continuing construction of buildings and roads they are further cleared leading to additional habitat loss and fragmentation.

METHODS

There are nine thicket fragments of different sizes at the campus of the University of Dar es Salaam of which six were surveyed (Figure 1). The six fragments; their respective approximate sizes (in parenthesis) were Udasa thicket (101.62 ha), Septic thicket (12.88 ha), Mama Lishe thicket (5.42 ha), Msewe thicket (4.73 ha), Mosque thicket (3.34 ha) and Botany thicket (2.77 ha) (Figure 1).

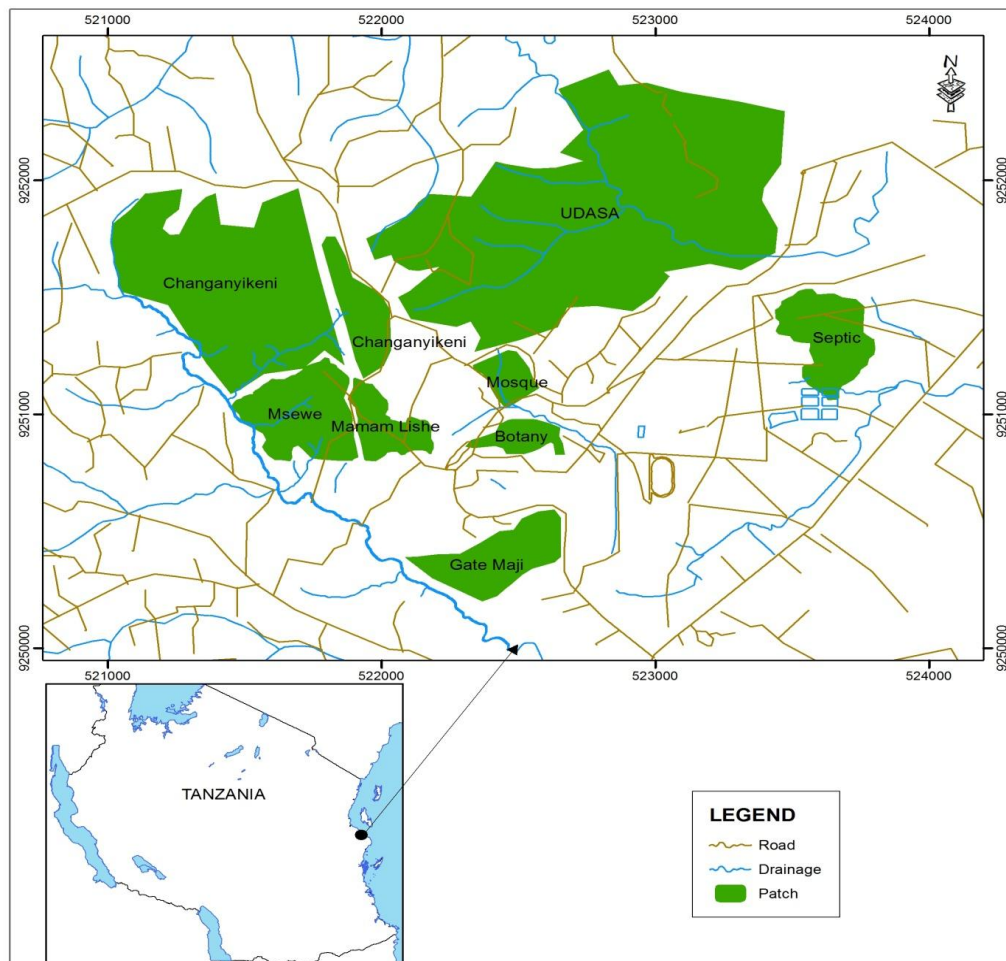


Figure 1: A map of the study area showing nine thicket fragments (patches). Map datum: Zone 37 M, World Global System (WGS) 84, May 2015.

In order to assess breeding bird species in the area, we conducted systematic physical searches of breeding individuals from November 2014 to the end of March 2015 which is the breeding season for most birds in East Africa (Moreau 1950) and coastal Tanzania in particular (Mlingwa 1996). Because of the variation in the size of the fragments, transects of variable width up to 50 m ranging in length from 100 m at Mosque fragment to 1000 m in length at the Udasa fragment (see Figure 1) were selected. In each fragment the search for nesting birds was carried out weekly.

In each transect we observed bird activity and behaviour, and then walked systematically through the entire transect in each fragment searching for nests. Systematic searches included visually inspecting vegetation, bare ground, cavities, stream (river) banks, and other suitable nesting locations. In addition, the following techniques were used: (i) birds carrying nesting materials were followed, nest(s) observed and later monitored weekly, (ii) birds carrying other materials, such as food were followed for possible detection of nests, (iii) calling nestlings were followed, (iv) birds making repeated flights to particular areas were followed for possible detection of nests, (v) tree cavities were checked for the signs of use, such as down or white wash on the rim of the cavity, (vi) existing nests were checked for the signs of occupation, such as evidence of fresh building materials, presence of eggs, and/or nestlings, and (vii) transects along the existing stream/river banks were surveyed for ground or hollow nesting birds.

An active nest was confirmed based on observations of the presence of an egg or eggs in a nest, calling nestling(s), and delivery of food for the young by adults. In cases where birds carrying nesting materials were followed, the nest was confirmed after

the eggs were laid. Numbers of confirmed active nests for each species were recorded.

We spent a total of 196.5 hours in all thickets. The numbers of hours spent in each thicket fragment were as follows: 80 hours at Udasa, 36 hours at Septic, 25 hours at Msewe, 21 hours at Mamalishe, 18 hours at Mosque and 16.5 hours at Botany (see Figure 1). Sampling effort (the number of hours spent in each fragment) was correlated with the size of the fragment ($r^2 = 0.979$, $p < 0.05$).

Shannon-Wiener index of diversity was used to determine nesting bird species diversity. Regression analyses were used to determine whether there were relationships between (i) number of nests and fragment size and, (ii) diversity of nest species and fragment size. In both cases, the areas of the fragments (ha) were log transformed to lessen the skewness of the area data. Species order, taxonomy and common names follow Sinclair and Ryan (2010).

RESULTS

Nesting species richness and abundance

In total, 107 active nests of 27 different bird species were located from all the six fragments (Tables 1 and 2). Larger fragments had more nests and species than smaller ones and nest abundance positively correlated with the fragment size ($r = 0.983$, $p < 0.001$; Tables 1 and 2; Figure 2). Only 27% (6 species) bred in the smallest fragments (< 4 ha).

Of the nesting species, a few were less affected by fragmentation. These include the Bronze Mannikin *Spermestes cucullatus* which was the most abundant, particularly in the small fragments and the Sunbirds, mainly the Collared Sunbird *Hedydipna collaris* and Olive Sunbird *Cyanomitra olivacea* (Table 2).

Table 1: Number of nesting species and nests, and nest species diversity of different fragments at Mwalimu Nyerere campus, University of Dar es Salaam between November 2014 and March 2015.

Aspect	Fragment					
	Udasa	Septic	Mama Lishe	Msewe	Mosque	Botany
Number of nesting species	24	8	5	5	3	3
Number of nests	47	29	10	11	8	3
Shannon-Wiener Diversity Index	2.998	1.669	1.557	1.468	0.7356	1.099

Table 2: Number of nests found in the study area per species for each thicket fragment at the campus, University of Dar es Salaam between November 2014 and March 2015.

Species	Fragment					
	Udasa	Septic	Mama Lishe	Msewe	Mosque	Botany
Hamerkop <i>Scopus umbretta</i>		1				
Red-eyed Dove <i>Streptopelia semitorquata</i>	1					
Emerald-spotted Wood Dove <i>Turtur chalcospilos</i>	4					
White-browed Coucal <i>Centropus superciliosus</i>	1					
Speckled Mousebird <i>Colius striatus</i>	2					1
Woodland Kingfisher <i>Halcyon senegalensis</i>	3					
Brown-hooded Kingfisher <i>Halcyon albiventris</i>	1					
Red-fronted Tinkerbird <i>Pogoniulus pusillus</i>	1					
Cardinal Woodpecker <i>Dendropicops fuscescens</i>	2	6				1
Fork-tailed Drongo <i>Dicrurus adsimilis</i>	1					
Black-headed Oriole <i>Oriolus larvatus</i>	1					
Indian House Crow <i>Corvus splendens</i>	1				1	
Dark-capped Bulbul <i>Pycnonotus tricolor</i>	2	1				
Sombre Greenbul <i>Andropadus importunus</i>	1					
Rattling Cisticola <i>Cisticola chiniana</i>	2					
Black-backed Puffback <i>Dryoscopus cubla</i>				1		
East Coast Boubou <i>Laniarius sublacteus</i>	1					1
Brown-headed Tchagra <i>Tchagra australis</i>	1				1	

Species	Fragment					
	Udasa	Septic	Mama Lishe	Msewe	Mosque	Botany
Black-headed Tchagra <i>Tchagra senegala</i>	1					
Scarlet-chested Sunbird <i>Chalcomitra senegalensis</i>	2		2			
Olive Sunbird <i>Cyanomitra olivacea</i>	4	1	3	3		
Collared Sunbird <i>Hedydipna collaris</i>	6		2	4		
Variable Sunbird <i>Cynnyris venustus</i>			1			
Vitteline-masked Weaver <i>Ploceus vitellinus</i>	3					
Lesser-masked Weaver <i>Ploceus intermedius</i>	3	1				
Zanzibar Red Bishop <i>Euplectes nigroventris</i>		6				
Bronze Mannikin <i>Spermestes cucullatus</i>	1	11	2	1	6	
Red-cheeked Cordon-bleu <i>Uraeginthus bengalus</i>	2	2		2		
Total number of nests	46	29	10	11	8	3

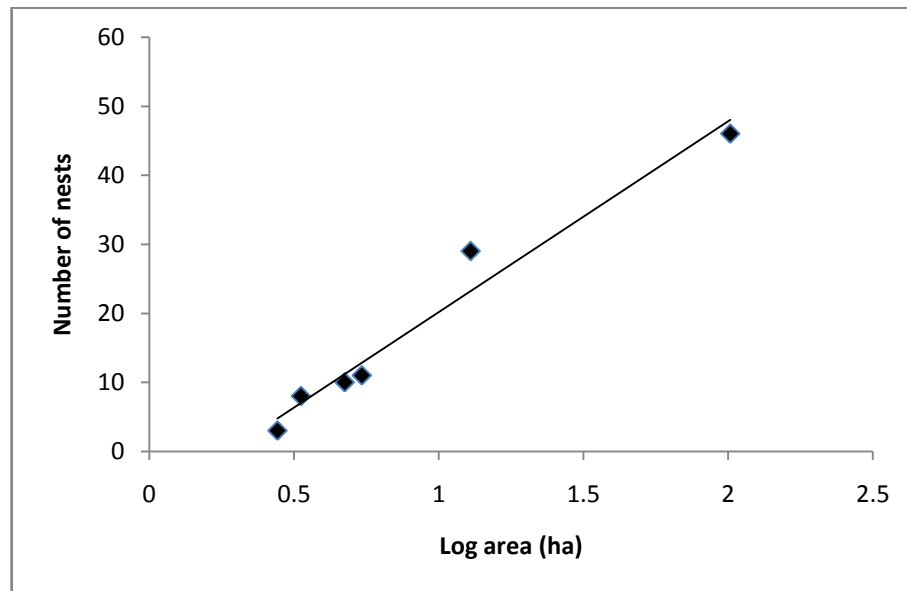


Figure 2: Relationship between number of nests and area of the thicket fragment at the campus, University of Dar es Salaam between November 2014 and March 2015.

Diversity of nesting species

Larger fragments had higher diversity of nest species than smaller ones and the diversity of nesting bird species increased

with fragment size ($r = 0.990$, $p < 0.0005$, Table 1, Figure 3).

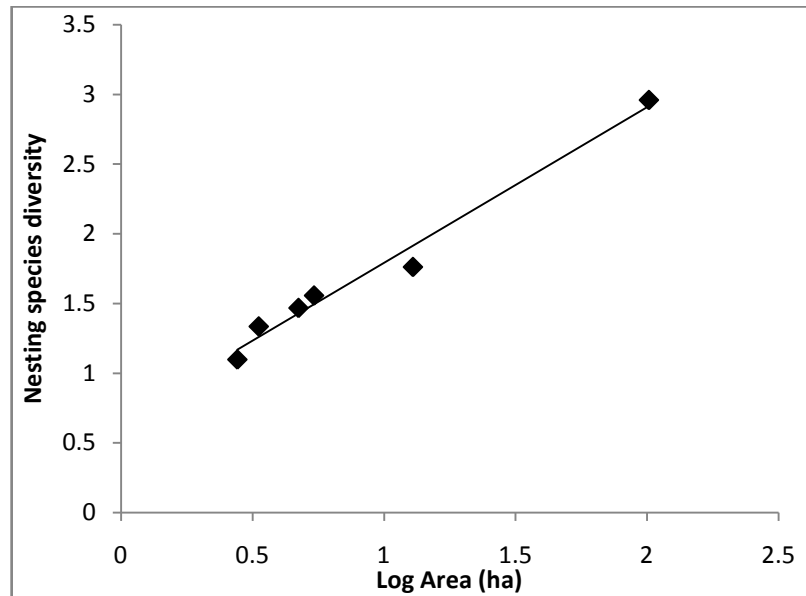


Figure 3: Relationship between nest diversity of bird species and fragment size at the campus, University of Dar es Salaam between November 2014 and March 2015.

DISCUSSION

On the University of Dar es Salaam's main campus thicket fragments, the number and diversity of nesting bird species found within the six thicket sites were related to the size of the fragments. Larger thicket fragments contained more nesting bird species and had higher diversity of nesting species than smaller fragments. These results are consistent with the findings of Galli et al. (1976), Martin (1981), Ambuel and Temple (1983), Blake and Karr (1984), Freemark and Merriam (1986), Blake and Karr (1987), Dowsett-Lemaire (1989) and Jokimäki (1999) who found that reductions in size of fragments adversely affect nesting bird species. In smaller patches, resources may be reduced, leading to both lower number of nesting bird species and lower diversity of nesting species compared to

larger fragments. As a result the minimum area requirements of the individual bird species would not be fulfilled in smaller fragments (Jokimäki 1999). These results further suggest that smaller thicket fragments have already experienced a loss of species following habitat fragmentation as has been found by Newmark (1991) in the Usambara Mountains, Tanzania. Nesting birds may avoid small habitat patches possibly due to higher nest predation rates as was found by Moller (1988) and Jokimäki (1999).

The sunbirds (Collared Sunbird, Olive Sunbird, Scarlet-chested Sunbird and Variable Sunbird) and Bronze Mannikin were nesting both in larger and smaller thicket fragments. All these species are non-forest dependent (forest visitors) except the

Olive Sunbird (Bennun et al. 1996) suggesting that they can live and nest in fragmented habitats and are relatively less affected by decrease in size of the thickets.

Of the bird species that have been recorded at the campus thickets by Harvey and Howell (1987) and Mlingwa (1992), only a few were found to nest during the study. This could be due to the secretive behaviour of some nesting species (Dranzoa 2001) or predation pressure, which is a common phenomenon in small forest patches (Askins et al. 1987).

Our study provides baseline information on the nesting birds in this area and shows that most of the birds need large areas of habitat for breeding purposes suggesting that fragmentation negatively affects diversity and abundance of nesting birds. While it is difficult to create corridors to connect the existing thicket fragments because of anthropogenic structures such as roads, buildings and electricity power lines, continued conservation of the remaining thickets is of high importance for the avifauna of the campus. Any further habitat clearing should be done only after detailed environmental impact assessments because the thickets in the University of Dar es Salaam play an important role as habitat refuge for urban wildlife in the Dar es Salaam area (Harvey and Howell 1987, Mlingwa 1992, Senzota 2012). With further habitat fragmentation and degradation, ecological requirements of most species may be compromised.

ACKNOWLEDGEMENTS

We are grateful for help from Paul Ginga for assistance in the field. We thank the University of Dar es Salaam for permission to undertake the study at the campus thicket fragments. We thank Ramadhani B.M. Senzota (posthumously), Kim M. Howell and Flora Magige for constructive comments in the draft of this manuscript.

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